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Sustainable Attrition-Resistant Oxygen-Carriers for Chemical-Looping Reforming by Spray Drying

Oxygen-Carriers

First Gen. Ni-based
- High cost
- S-poisoning
- Toxicity
- Harm to environment

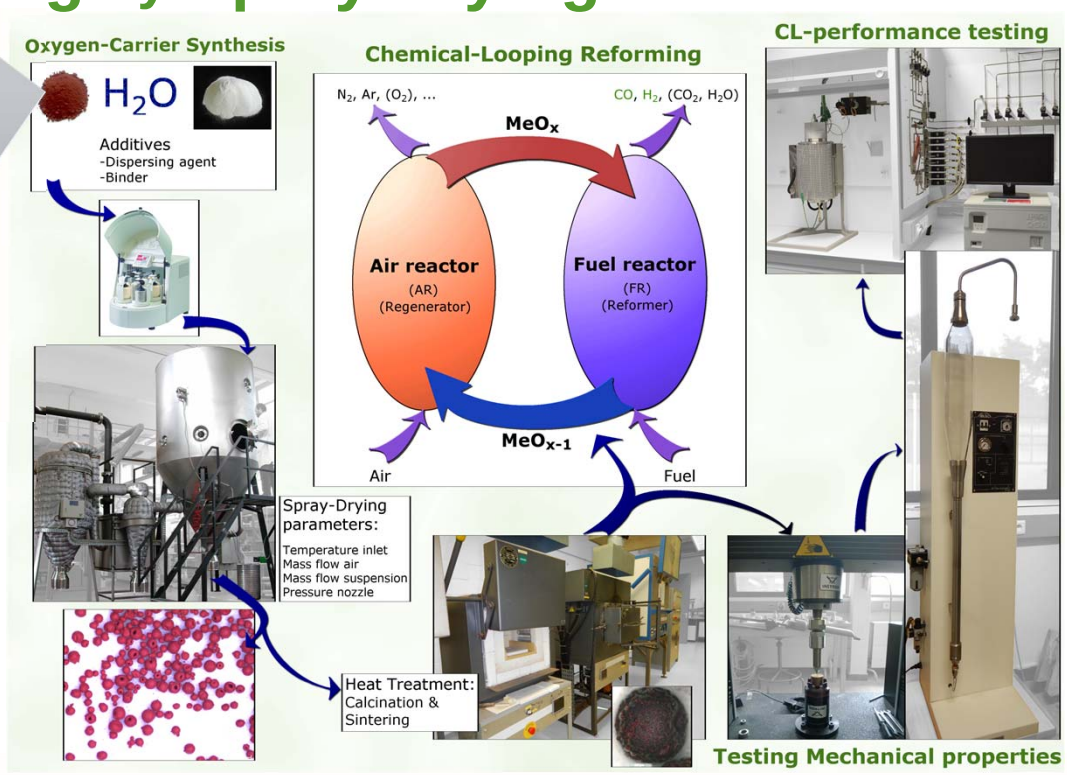
New Gen. → Fe-based
- Much more cheap
- Less deactivation
- Non-toxic
- Environment-friendly

Material	Lifetime in reactor
$Fe_2O_3/\gamma\text{-}Al_2O_3$ (impregnation)	1100 h
$NiO/\ \gamma\text{-}Al_2O_3$ (impregnation)	5300 h
$NiO/NiAl_2O_4$ (spray-drying)	33000 h

← Lower lifetime

Mechanical properties need improvement
- |Strength
- |Attrition resistance

Spray-drying → spherical particles → Improved attrition-resistance

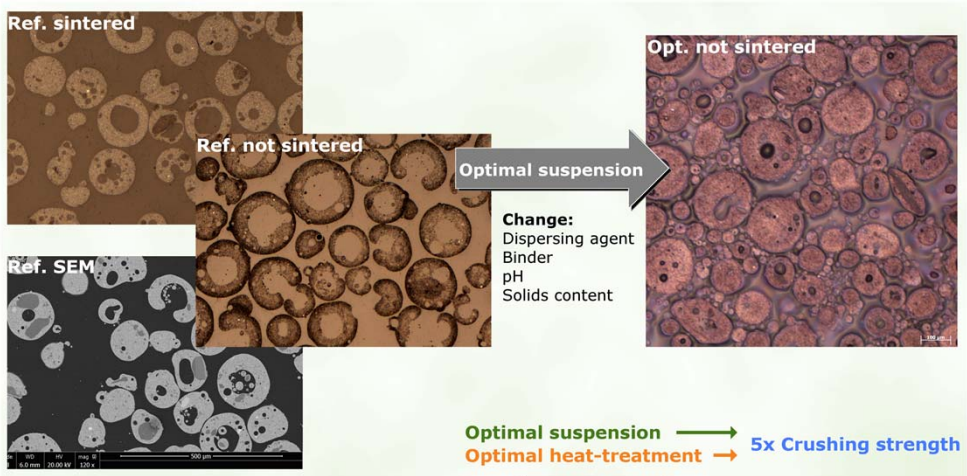


Increase viability of CLR by developing Fe-based O-carriers

Use of spray-drying yields spherical oxygen-carriers.

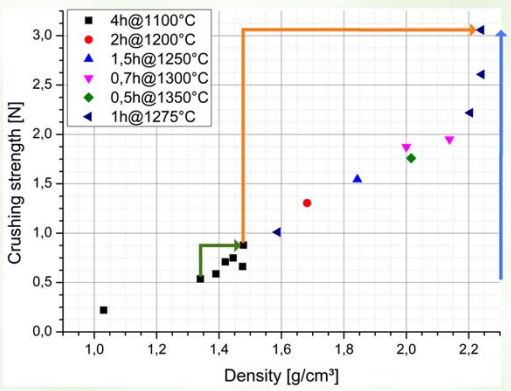
By optimizing the composition of the suspension used in the spray-drying process and the heat treatment of the resulting particles, the strength of the oxygen-carriers increased five-fold.

Chemical-looping tests in future research will investigate the chemical performance of the synthesized materials.



Sample	Tapping density [g/cm³]	Crushing strength [N]
Ref. green	1,3	
Opt. green	1,4	
Ref. 4h@1100°C	1,4	0,59
Opt. 4h@1100°C	1,6	1,06
Opt. 1h@1275°C	2,3	3,06

Optimal suspension → 5x Crushing strength
Optimal heat-treatment →



First spray dried particles → defective morphology
- → **Inhomogeneous** microstructure
- → **Hollow** particles → Crushing strength 0,6 N → Improvement needed

Optimization of the **suspension**
- ✓ Dispersing agent
- ✓ Binder
- ✓ Water
- ✓ pH

→ Tapping density increases (1,3 g/cm³→1,4 g/cm³)

Optimization of **sintering temperature**
- → Phase transition to $FeAlO_3$ @ 1320°
  - → Lower density and strength
  - → Magnetic properties change
- ✓ Optimized to 1h@1275°
- → Sintering time

→ Tapping density & strength increases (to 2,3 g/cm³ and 3,1 N)

→ Tapping density particles correlates with strength
- → Attrition-resistance?
- → Trade-off between mechanical and chemical properties (porosity/strength) → Future research

Track 3: CCU – Closing the carbon loop: Carbon dioxide Capture and Utilisation
Yoran De Vos, Marijke Jacobs, Pascal Van Der Voort, Isabel Van Driessche, Frans Snijkers, An Verberckmoes
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